

XVIII.—*Notes on some Silicates of Copper, with remarks on the Chrysocolla Group.*

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THE vast commerce of Liverpool enables those resident in it to observe some very interesting mineralogical facts, though its position among the gently undulating hills of the New Red Sandstone deprives them of the opportunity of collecting indigenous minerals.

Having in the course of the past few years specially studied some of the chrysocolla ores imported there, I have been very much struck with the vast differences to be detected in most of their physical characters. These differences in fact are of such importance, as will be seen in the sequel, that I have thought it advisable to mention them to some of our ablest English mineralogists and at their request I have been tempted to insert a record of them in the pages of the Mineralogical Magazine. From collections made of these minerals in other localities I have been enabled to make some interesting comparisons, but before stating any of the deductions I have made from these, it will perhaps be better to mention briefly some of the chief characteristics of the stones from different localities.

No. 1.—*From Lower California.*

This large stone shows strikingly a series of gradations from the light earthy variety of chrysocolla, with hardness 1, to the vitreous variety, hardness 5. Beautiful dendritic formations of manganese ore are scattered throughout the specimen, and kupferpecherz is also present. Commencing with the vitreous variety we find it of a dark bluish green colour; this passes gradually into a lighter shade, until we reach a variety with the faintest tinge of blue green, almost white. The light coloured variety is quite adherent and fuses in blowpipe flame, while the dark-coloured variety (typical chrysocolla) is quite infusible, and is non-adherent. Thin veins of the vitreous variety permeate the other, and a layer of calcedony covers them both; this, in its turn, is covered by a layer of calcite crystals.

No. 2.—*Same locality.*

Similar to the light earthy variety described above, but so porous that it floats on water. Colour light blue green. Hardness 1 to 1½. Remarkably absorbent of water (as much as 80 p.c.), and when saturated becomes of a much darker colour. Fuses before the blowpipe. Mr. W. N.

Hutchings, F.I.C., whose assistance in these examinations I would here acknowledge as being of the highest possible value, has analysed this variety, with the following result, which I have placed for comparison with an analysis made by the same gentleman of the hard and vitreous variety from another portion of the same stone.

	Variety—Hard and Vitreous.			Variety—Soft and Earthy.		
Si O <sub>2</sub>	..	..	67·07	..	..	46·45
Cu O	..	..	24·95	..	..	39·15
Pb O	..	..	·26	..	..	·41
Fe <sub>2</sub> O <sub>3</sub>	..	..	·27	..	..	·48
Al <sub>2</sub> O <sub>3</sub>	..	..	·55	..	..	3·65
Zu O	..	..	·09	..	..	·10
Ca O	..	..	·81	..	..	·80
Mg O	..	..	·37	..	..	·82
H <sub>2</sub> O	..	..	5·82	..	..	7·99

These minerals were heated to 95° Cent., for some hours, and the water determined by heating to redness.

No. 3.—*Same locality.*

Layers of amorphous felspar and calcedony, sometimes containing crystalline quartz. The felspar, apparently when unchanged of a dull greyish brown colour, passes through various shades of blue to a very dark blue, at the same time becoming richer in silica, and much harder. The silica appears to increase still more until the variety is hard enough to scratch glass. In one instance, this hard blue variety graduates into almost pure calcedony of a dull grey colour.

No. 4.—*Same locality.*

A series of layers, each about 2 millimetres, of gypsum, soft brown hepaticerz, black kupferpecherz and atacamite, with calcite.

No. 5.—*Same locality.*

Resembles vari-coloured jasper so much in appearance, that were it not for an unmistakable piece of typical chrysocolla of the usual hardness thereon, it would probably be taken as such. The colours are blue, bluish green, brown, grey of all shades, from black on one side to white on the other. Dendritic manganese ore is disseminated throughout the entire mass. In some cases there is semi-opalescent quartz mixed with the chrysocolla.

No doubt can be entertained that this stone represents various stages of deposits of copper and silica in solution, sometimes the one, at other times the other, in excess. The solution would also at times have more or less iron or manganese present. The analysis of this hard vitreous variety

shows no less than 67 p.c. silica and 5.8 water, so that the surmise by Berthier, of opal silica being present is probably correct, as both physical and chemical examinations confirm it.

No. 6.—*Same locality.*

A stone of great beauty from the brightness of the colours of the chrysocolla. It consists of irregular layers of "jaspery" chrysocolla (hard enough to scratch glass) and a softer variety hardness 2 and 3. The colours of this jasper variety are various shades of blue, from sky to a deep tint, brown and grey. They all have a roughish conchoidal fracture. In certain portions of the stone are found a decomposing mineral which breaks into irregular pieces, and somewhat resembles starch in appearance. This is found to be composed of an intimate mixture of the chloride and silicate of copper, evidently a passage from the former to the latter. It thus reveals the fact that some, and probably much of this Mexican chrysocolla has been formed by the action of waters containing silica, on the chloride of copper, "atacamite." The occurrences of pseudomorphs of chrysocolla after atacamite, hereafter described, confirm this deduction. In one place the silica, after altering the atacamite, has reached a small fissure, and still retaining copper has deposited along the margin a layer of vitreous chrysocolla, this passes gradually into grey calcedony, and then into quartz crystals, which line the cavity in a similar manner to that sometimes seen in the interior of agate stones, when broken open.

A remarkable fact revealed on the examination of some hundreds of tons of these chrysocollas from Lower California, was the absence of any trace of carbonates in them. In some other lots from same locality, minute portions of carbonate were met with, but always the blue variety, "chessylite," (azurite). The carbonate, moreover, appeared to occur in those stones having a soft earthy decomposed character and containing many minerals, rather than with those more defined in their composition. The minerals occurring with these ores are gypsum, calcite, baryte, quartz, calcedony, smithsonite, and pyrolusite.

No. 7.—*From Utah.*

Is composed of both brown and bluish green varieties. The fibrous radiations of malachite pervade the stone, and as some of these are completely converted into chrysocolla, the stone possesses great interest.

No. 8.—*Same locality.*

Principally composed of the brown and hepatinerz varieties. In a cavity about  $\frac{1}{2}$  inch wide at the mouth are several small stalactites of semi-crystalline chrysocolla.

No. 9.—*Same locality.*

Composed of a dark brown variety, with hardness of 5 to 6, with some beautiful incrustations of minute crystals of azurite.

No. 10.—*From Chili.*

In this stone are nodules of a brown red variety, encircled by the blue. As the depth of the blue increases as the kernel (other colour) is neared, there seems to be a connection between the two. The red probably existed formerly as cuprite or native copper, and has since been decomposed. This view of the origin of chrysocolla is maintained by Dr. Burghardt. It is interesting to notice that at one portion of the stone minute crystals of diopside are met with, while in another, quartz crystals, with native copper interspersed between them, are found.

No. 11.—*From Peru.*

As typical of a parcel some 300 tons this is instructive. It consists of a mixture of chrysocolla, malachite and atacamite, the latter two being generally crystallized. As some characteristic crystals of atacamite are partially converted into malachite, and this passes into chrysocolla, it would appear that the above sequence represents the age of these minerals in this locality. I also find crystals with the characteristic form of malachite converted into a silicate of copper.

No. 12.—*From Peru.*

Represents another large importation of quite a different character. It looks as if it had been subjected to decomposing agencies. Numerous cavities occur in which the chrysocolla is almost crystalline. In some instances layers of small quartz crystals are found, and on these very minute crystals of diopside of a rich emerald green occur.

No. 13.—*Same locality.*

Contains a mixture of granular atacamite with chrysocolla and radiated masses of malachite. On the exterior portion are minute crystals of sulphate of copper of a greenish colour tinged with blue.

No. 14.—*From Cornwall.*

One of the typical specimens from the celebrated Wheal Gorland mine. Contains well defined crystals of olivenite on pseudomorphous layers of quartz. At the base is a mass of green chrysocolla passing into kaolin. It fuses with ease before the blowpipe.

No. 15.—*From Cornwall.*

A piece of ordinary Cornish granite from South Carn Brea mine. It has a small vein of cuprite about 2 millimetres wide through it. The felspar

crystals on either side have been partly converted into chrysocolla, and this alteration is greatest as the cuprite is neared. The small quartz crystals seem to be surrounded with layers of chrysocolla, while the mica has been quite changed into thin hexagonal flakes of a bright green colour, resembling chalcophyllite.

No. 16.—*From Cornwall.*

This stone, from South Caradon mine, shows very clearly how chrysocolla may be formed by the decomposition of other copper ores. One portion consists of almost pure kaolin; but in another part several nodules of chrysocolla surrounded inner kernels of chalcocite. Examining one of these nodules we find the central portion to be quite compact chalcocite, with the ordinary streak and sectility of that mineral. Proceeding outwards, the streak becomes less metallic and nearly earthy, of a white colour. The mineral assumes gradually a reddish-brown colour, as if some small quantity of iron present had been converted into oxide, and then a layer of chrysocolla is reached. This is first of a deep blue colour, and then shades gradually away to pure white kaolin. The depth of its blue colour appeared to coincide inversely with the adherency of the stone, as if with the increased per centage of copper, the kaolin lost its ordinary property of adhering to the tongue.

No. 17.—*From Cornwall.*

This stone, from the same mine as the foregoing, has small portions of chrysocolla attached to what appear hollows occupying the place of what were once crystals of felspar. No trace of the copper ore from which it has been derived can be seen, but a large portion of the stone is composed of a brown variety containing iron, copper, and clay.

DIOPTASE.

No. 18.—*From Peru.*

This beautiful mineral is found in very small crystals of a bluish green and emerald green colour, on small quartz crystals, in what is evidently a mass of decomposing copper ore.

Although until Dr. Burghardt's description was published, I am not aware of any mention being made of them, I find from that most profound mineralogist, Mr. Thomas Davies, F.G.S., of the British Museum, that the National Collection possesses several specimens from this locality, and it is by no means a rare mineral in that part of the world.

COPPER PITCH BLENDE (KUPFERPECHERZ).

No. 19.—*From Lower California.*

Associated with the large masses of chrysocolla from Lower California are nodules and veins of a dark-brown or black mineral having the lustre of pitch.

The nodules vary in size from  $\frac{1}{2}$ " to 6" in largest diameter, and the veins from  $\frac{3}{8}$ " to 2" in width. Like the different varieties of chrysocolla before described, the hardness is extremely variable, some being about 2, others as high as 6. The fusibility seems to vary with the hardness, and the proportion of manganese contained also exerts an influence on the fusibility, as the higher percentage of manganese the more fusible the stone.

Disseminated through the copper pitch-blende are minute portions of atacamite and chrysocolla, while the minerals associated with it are gypsum (fibrous variety), pyrolusite, calcite, barytes, jasper, calcedony, and quartz.

The following analyses by Mr. W. N. Hutchings, F.I.C., reveal the chemical composition of the fusible and infusible varieties:—

	Infusible.	Fusible.
Silica .. .. .	27.98	11.95
Oxide of Copper .. .. .	28.59	14.20
Oxide of Lead .. .. .	.41	..
Oxide of Iron .. .. .	10.94	9.35
Oxide of Zinc .. .. .	1.45	.80
Lime .. .. .	.92	2.41
Water .. .. .	8.30	11.61
Alumina .. .. .	.15	..
Oxide of Manganese .. .. .	17.53	38.53
,, Cobalt .. .. .	.35	.95
Oxygen .. .. .	3.60	7.89
Sulphuric Acid .. .. .	..	.16
Magnesia .. .. .	..	2.35
	100.31	100.20

No crystals are met with, or in fact any appearance of crystalline structure. This variety I should consider a typical example of copper pitch blende, and its physical characters may be thus summarized:—Colour, brown, black; streak same as colour; lustre, pitch-like; hardness, 2 to 6; fracture imperfectly conchoidal.

*Hepatinerz.*—The liver-coloured variety is met with to a fair extent in the Mexican ores, and sometimes enclosed in it are nodules of the appearance and colour of serpentine. In the analysis of these hepatinerz stones the proportion of oxide of copper was found to be 22 per cent., or rather less than in the copper-pitch blende, but probably there is a great amount of variation in the percentages of different varieties.

#### PSEUDOMORPHS OF CHRYSOCOLLA AFTER ATACAMITE.

##### No. 20.—*From Peru*

In the course of my examinations of the foregoing specimens, I was much struck with the paucity of crystal forms met with. On closely examining with a lens what looked like a mass of minute stalactites of

chrysocolla on a body of atacamite, I found they were in reality minute crystals of atacamite covered by a thin layer of chrysocolla. It seemed as it were that the quondam crystals of atacamite were being slowly changed into stalactites of chrysocolla. Further examinations enabled me to find two specimens where the crystalline form of the atacamite is preserved, while its composition has been changed. The crystals were of peculiar shape, thin tabular plates, and when unaltered resembled "Torberite." It was most interesting to trace the gradual change, as some crystals were scarcely altered whilst others were perfectly changed into chrysocolla.

No. 21.—*From Lower California.*

In this case the crystals are of the usual form—long prisms with usual terminations. They have been completely converted into chrysocolla. In one instance a crystal being broken shows a beautiful section. The central portion has two small holes similar to those seen in "blue lead" crystals and a thin light blue powder can be obtained in very small quantities scattered through the crystal. This is found to be largely composed of chloride of copper and silicate, thus confirming the conclusions drawn from other stones previously described. I believe this is the first notice of the replacement of atacamite by chrysocolla, but I think further examinations will show this has frequently been the case. Previous to this, chrysocolla has been described as occurring pseudomorphic after malachite, chalcophyllite, cuprite, libethenite, galena, cerusite, and barytes. Collins' hand-book to the minerals of Cornwall and Devon also mentions "mica." I have, however, very little doubt that an examination of many of the copper minerals in old collections will show that chrysocolla is the replacing mineral where malachite has sometimes been supposed to be.

From examinations of the specimens described in the foregoing pages, we find that the hardness of these chrysocolla minerals is extremely variable, from 2 to 6 on Mohs' scale; the fusibility also differs in like manner. Further we find that every gradation can be traced from ordinary typical chrysocolla to kaolin on the one side, and quartz on the other. We also find it can be derived from several ores of copper, as we have traced it from cuprite, malachite, chalcocite, atacamite and olivenite.

It can evidently be formed in more ways than one. In specimen No. 16, where a gradual change can be seen in the condition of the ore acted on and also in that of the kaolin surrounding, there seems but little doubt of its resulting from the action of these minerals on each other in the presence of water.

In specimen No. 6, atacamite has probably been acted on by water containing silica in solution. This has converted it into chrysocolla, and the

water passing on charged with both silica and copper in solution, has deposited a layer of chrysocolla as described.

In No. 5 the mineral seems to have been deposited from a solution in which both copper and silica were present, sometimes the one sometimes the other in excess. Diopside crystals would seem to be formed when the correct proportions for this mineral existed in the solution of copper and silica, and the conditions were favourable for crystallization. It appears to me that some of these masses of so-called chrysocolla may after all be amorphous "diopside." The nodules and layers of copper pitch blende are probably segregations of a manganese compound from the surrounding mass, as are also the dendritic formations of this mineral and pyrolusite.

The wide differences in the component chemical compounds seem to preclude the possibility of fixing any definite formula for the mineral. Prof. Dana (System of Mineralogy, p. 403) gives the results of 15 analyses of chrysocolla, in addition to the analyses of 11 impure varieties on p. 404.

An examination of these fifteen shows the following.—

	Minimum.	Maximum.
Oxide of copper ..	28 per cent.	45 per cent.
Silica .. .. .	26 ,,	52 ,,
Water .. .. .	16 ,,	31 ,,

Some of Mr. Hutchings's analyses are even more striking, showing—

	Minimum.	Maximum.
Oxide of Copper ..	25 per cent.	39 per cent.
Silica .. .. .	47 ,,	67 ,,

The percentage of silica in ordinary chrysocolla is thus found to vary from 26 p.c. to 67 p.c., and that of the oxide of copper from 25 p.c. to 45 p.c., while water exists in about double the proportion in some varieties than in others. To calculate a formula, which without undue extension or allowance will include all the varieties before named, would tax the powers of our most mathematical chemist. The varieties so merge into one another that it is quite impossible to divide them into separate species.

I have therefore been led to the conclusion that the term "chrysocolla" should be taken to represent a group of hydrated silicates of copper, which vary much in chemical composition, physical characters, and blowpipe behaviour. The term "Kupferpecherz" I should restrict to those varieties of a dark-brown or black colour resembling "pitch" in lustre. "Hepatinerz" I would restrict to those of a liver-colour, if indeed it should be retained at all.

By so doing, we get rid of the absurdity of describing as a definite mineral compound, a class of compounds not one of whose properties is



constant throughout the group. However, by retaining the name "chrysocolla" for the group we avoid the necessity of creating a vast number of new names, for each variety which possesses some character different from the other members of the group would otherwise be entitled to a separate title. Mineralogists can well spare a large number of names which are given to "species" on what seem very insufficient grounds, and I trust one of the advantages conferred on the science by the formation of the Mineralogical Society will be a more rational and complete Mineralogical classification than we at present possess.